With reference to point (4), it is admitted by Morgan and his associates that "double crossing-over has no meaning, if three genes are imagined as not lying in a straight line." It is accordingly a secondary hypothesis needed to help out the hypothesis of linear arrangement, but it can not be cited as proof of that hypothesis, which must stand or fall on its own merits. I can see no reason *a priori* why two or more breaks should not occur simultaneously in different parts of a linkage system, whether linear or non-linear, but this is no evidence that, every time a particular gene separates from two others, it has done so by two independent breaks, the view necessitated by the linear hypothesis. The relation of certain observational facts to the idea of double crossing-over is correctly stated by Plough[5] in relation to the alternative hypotheses. On a non-linear hypothesis, temperature affects "long chromosomal distances" (high cross-over values) less than small ones; on the linear hypothesis, temperature acts by changing the frequency of double crossing-over. This is no proof of either hypothesis, but a statement of fact in terms of each.

[1] Sturtevant, A. H., Bridges, C. B., and Morgan, T. H., these PROCEEDINGS, **5**, 1919, (168).

[2] Castle, W. E., these PROCEEDINGS, **5**, 1919, (25).

[3] Morgan, T. H., and Bridges, C. B., "Sex-linked inheritance in Drosophila," *Carnegie Inst., Washington Publ.*, No. 237, May 8, 1916.

[4] Castle, W. E., these PROCEEDINGS, **5**, 1919, (32).

[5] Plough, H. H., these PROCEEDINGS, **5**, 1919, (167).

ON VARIATION IN TARTARY BUCKWHEAT, FAGOPYRUM TATARICUM (L.) GAERTN.

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Introductory.—From the morpho-genetic point of view the manifestation of dimorphism in certain races of plants—the so called ever-sporting varieties—presents a very interesting problem. The remarkable feature of these races is the constancy with which the two diverging forms of the same organ are transmitted in ever-sporting fashion: no breeding method has, as yet, been conceived by which, for instance, certain variegated types of plants or certain strains of Matthiola, could be induced to breed true. These races appear as compound forms ever-transmitting the potentialities of the two component types.

Dimorphism manifests itself in two externally different forms. The different characteristics may appear simultaneously distributed in the organs of the same individual as in *Trifolium pratense quinquefolium* De Vries or in *Veronica agrestis;* in another group of plants each individual of the race may display only one of the dimorphic characters as in the case of certain strains of Matthiola, Antirrhinum, *Dipsacus sylvestris torsus*, etc.

In interpreting these phenomena, De Vries whose investigations involved a great abundance of material, assumes the peculiar behavior of these races to be due to the interaction of two "antagonistic, mutually exclusive characters." The operation of these two contending characters within the individual leads to the formation of two distinct groups of plants, the half-races and the middle races or ever-sporting varieties. Opposed to this interpretation is the view held by certain writers who consider the ever-sporting nature of many of these races as mere somatic variations and relegate them into the group of non-heritable modifications.

More recently, however, some of the ever-sporting types in plants as well as in animals have been subjected to a genetic analysis and their peculiar mode of inheritance has been explained on Mendelian grounds.

The purpose of the present communication is to record the results of a study on a highly variable, ever-sporting race which I have discovered in *Fagopyrum tataricum* Gaertn. (*Polygonum tataricum* Linn.). In the course of observations on this race my attention was chiefly devoted to the study of variation and transmission of the external characters in an endeavor first to establish by direct experiment the behavior of this race under different conditions before attempting an analysis of the underlying genetic causes.

The full account of this investigation will be published in *Genetics*.

Material and experimental methods.—The race with which the present account is concerned originated from commercial fruits of Fagopyrum tataricum, Tartary Buckwheat, which had grown in Maine. In a population of several hundreds of plants, one plant was found to be distinguished by a particularly high degree of variability in the structure of its flowers. This plant was selected as a starting point of a strict pedigree culture, and since its isolation in 1916 five generations have been grown. The study of floral variations of this race involved the examination of more than 57,000 flowers and fruits.

The manifestation of variations of this race was studied under different conditions of environment. The cultures grew in pots under greenhouse

conditions and in the garden. Two greenhouses were used whose conditions differed greatly, notably with respect to humidity and temperature. In one of the greenhouses prevailed what might be called a moist and hot condition, the temperature varying only slightly, from 75°F. during the day to 70°F. at night. In the other greenhouse where the cultures grew in the summer time no artificial heat was used, the temperature following the natural daily amplitude. The air in this greenhouse was quite dry.

In connection with the study of the effect of nutrition and starvation upon the teratological development of this race, the cultures were grown in different nutritional media comprising rich composted or fertilized soil, ordinary soil, sand, and gravel.

Observations and results.—The variations here considered occur in the gynoecium, the perigone, and the vegetative organs of this race. Most of these variations have hitherto not been recorded for Fagopyrum tataricum.

The variations in the gynoecium are characterized by the production of supernumerary carpels. The number of carpels per pistil was found to vary from 3 up as high as 25. Under ordinary conditions of growth the number of flowers with normal gynoecia predominates over or equals the number of flowers with abnormal gynoecia. Under conditions favoring the development of abnormal flowers the variation is bilateral, and can be represented by a curve the apex of which is formed by the abnormal four-carpelled flowers. The frequency distribution of flowers with respect to number of carpels is given in table 1.

From table 1 it will be noted that the frequency distribution of flowers with abnormal gynoecium decreases as the number of aberrant carpels per pistil increases.

Associated with the abnormal gynoecia are abnormal perigones with a varying number of segments ranging from the normal number of 5 as high as 18. The favorable conditions capable of transforming the unilateral variation of the gynoecia into a bilateral one, failed to affect the perigones in the same manner. The variation in the number of perigone leaves remained unilateral with the frequency of the normal, five-parted perigone forming the apex of the skew curve (table 2).

The frequency of the normal, five-parted perigones decreases as the number of carpels per pistil increases. The relationship between the number of carpels and perigone leaves is illustrated in table 3.

All descendants of the ever-sporting race were found to reproduce the ever-sporting type of the mother plant regardless of whether they originated from normal or abnormal fruits of the parent.

TABLE 1

ACTUAL AND PERCENTAGE FREQUENCIES OF NUMBER OF FLOWERS WITH REGARD TO NUMBER OF CARPELS

PLANT NUMBER	3		4		5		6		7		8		9		10	
	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age
Pot 36 1	78	17.69	320	72.56	27	6.12	5	1.13	2	0.45	1	0.23	1	0.23	2	0.45
Pot 36 2	49	14.41	249	73.24	17	5.00	10	2.94	1	0.29	3	0.82			1	0.29
Pot 36 3	119	19.97	389	65.27	46	7.72	10	1.69	3	0.50	10	1.68	3	0.50	5	0.84
Pot 37 4	130	16.62	520	67.01	66	8.51	14	1.80	5	0.64	10	1.29	10	1.29	5	0.64
Pot 37 5	136	20.80	430	65.60	51	7.80	8	1.22	6	0.92	7	1.07	1	0.15	3	0.46
Pot 37 6	150	21.08	488	68.54	49	6.88	7	0.98	3	0.42	2	0.28	2	0.28	4	0.56
Pot 39 7	127	15.05	572	67.77	67	7.94	24	2.83	9	1.07	7	0.83	4	0.47	8	0.95
Pot 39 8	190	17.48	719	66.51	101	9.34	15	1.39	6	0.56	7	0.65	6	0.56	13	1.20
Total..	979		3687		424		93		35		47		27		41	
Percent-age..	17.98		67.73		7.79		1.71		0.64		0.86		0.49		0.75	

PLANT NUMBER	11		12		13		14		15		16		17		18		19		SYNANTHIES		TOTAL
	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	Actual	Percent-age	
Pot 36 1	1	0.23					1	0.23											3	0.68	441
Pot 36 2							1	0.29											9	2.65	340
Pot 36 3			1	0.17															10	1.68	596
Pot 37 4			2	0.26							1	0.13							13	1.68	776
Pot 37 5																			12	1.83	654
Pot 37 6																			7	0.98	712
Pot 39 7			8	0.95	2	0.24											1	0.12	15	1.78	844
Pot 39 8	3	0.28	5	0.46	1	0.09	1	0.09							1	0.09			13	1.20	1081
Total..	4		16		3		3				1				1		1		82		5444
Percent-age..	0.07		0.29		0.06		0.06				0.02				0.02		0.02		1.50		

TABLE 2

ACTUAL AND PERCENTAGE FREQUENCIES OF NUMBER OF FLOWERS WITH RESPECT TO NUMBER OF PERIGONE LEAVES

PLANT NUMBER		NUMBER OF PERIGONE LEAVES																TOTAL
		5		6		7		8		9		10		11		12		
		Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	
Pot 36	1	308	70.32	105	23.97	18	4.11	4	0.91	2	0.46	1	0.23					438
	2	214	64.65	89	26.89	21	6.34	5	1.51	1	0.30	1	0.30					331
	3	410	69.97	141	24.06	23	3.92	7	1.19	3	0.51	2	0.34					586
Pot 37	4	541	70.90	162	21.23	37	4.85	14	1.83	1	0.13	7	0.92			1	0.13	763
	5	447	69.63	150	23.86	29	4.52	11	1.71			5	0.78					642
	6	538	76.31	131	18.58	28	3.98	5	0.71	2	0.28	1	0.14					705
Pot 39	7	604	72.86	169	20.39	31	3.74	13	1.57	7	0.84	5	0.60					829
	8	784	73.41	212	19.85	44	4.12	10	0.94	4	0.37	10	0.94	1	0.09	3	0.28	1068
Total		3846		1159		231		69		20		32		1		4		5362
Percentage		71.72		21.62		4.31		1.29		0.37		0.59		0.02		0.08		

TABLE 3

PERCENTAGE FREQUENCIES SHOWING RELATION BETWEEN NUMBER OF CARPELS AND NUMBER OF PERIGONE LEAVES

NUMBER OF PERIGONE LEAVES	NUMBER OF CARPELS																
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	89.68	71.30	58.96	35.48	54.29	42.35	48.15	36.59	25.00	56.25	33.33						
6	8.78	25.33	24.76	26.88	2.85	14.89	3.70										
7	1.33	3.09	14.15	23.66	11.43					6.25							
8	0.20	0.27	1.88	10.75	14.29	31.91	3.70	24.39	25.00		33.33	33.33					
9			0.24	3.23	17.14	2.13	18.52	7.32	25.00								100
10						8.51	25.93	26.83	25.00	31.25	33.33	33.33					
11								2.44									
12								2.44		6.25		33.33				100	
Total...	99.99	99.99	99.99	100.00	100.00	99.99	100.00	100.00	100.00	100.00	99.99	99.99				100	100

The ratio between the normal and abnormal flowers was found to be a function of the environment. Under a given set of environmental conditions this ratio as well as the relationship between the different forms of abnormal flowers *inter se* is constant to a very marked degree.

Selection carried out for five years had no visible effect upon the type and range of floral variations of this race. The ever-sporting strain after isolation at once displayed the highest degree of abnormality ever reached in the subsequent generations under similar conditions of environment.

Under conditions controlling the intensity of abnormal development, optimum nutrition or starvation, while affecting the habit of the plant, appeared to have no effect upon the degree of manifestation of floral abnormalities. The evidence from the study of this race under different conditions of environment points to high humidity and temperature as the factors favoring the expression of abnormality. Under conditions void of optimum humidity and temperature, the influence of starvation and lack of water upon the degree of abnormal development was noticeable.

The results of a study of the frequency distribution of the different types of flowers upon the plant point to the existence of a definite region on the plant in which the tendency to vary and proliferate is most pronounced. Considering the plant as a whole, this region is confined to the basal, differentiated parts of the plant. The frequency distribution given in table 4 shows that the first three branches on the main stem from below, especially the second one, mark the seat of greatest abnormal development while the racemes in the axils of the 4th, 5th, and 6th branch show a low degree of variability as well as the lowest absolute number of flowers.

Similar but more marked differences prevail in the individual branches of the second and third order. Here it is again the buds in the axils of the second leaf and in the basal region of the terminal raceme that show the greatest relative number of abnormal flowers as well as the greatest range of variability as measured by the frequency occurrence of the most aberrant variants.

Relative to the frequency occurrence of the different types of flowers at different periods of the flowering season, under the conditions prevailing in the greenhouse the first and second week of the flowering season mark the lowest relative production of abnormal flowers, after which a marked increase in the output of abnormalities follows when the secondary and tertiary branches begin to develop their flowers. Towards the end of the flowering season the upper regions of the plants produced only

TABLE 4

ACTUAL AND PERCENTAGE FREQUENCY DISTRIBUTIONS OF FLOWERS BORNE BY EACH ORGAN OF EACH PLANT, WITH RESPECT TO NUMBER OF CARPELS

POSITION OF FLOWERS	NUMBER OF CARPELS: 3		4		5		6		7		8		9		10	
	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage
In axils of Cotyledons........	97	16.33	389	65.71	60	10.14	15	2.53	3	0.51	5	0.84	3	0.58	4	0.68
On Branch 1....	234	18.75	829	66.43	105	8.41	21	1.68	8	0.64	19	1.52	6	0.48	12	0.96
On Branch 2....	245	18.39	880	66.07	98	7.36	25	1.88	14	1.05	8	0.60	4	0.30	15	1.13
On Branch 3....	242	17.60	927	67.42	111	8.00	25	1.82	8	0.58	13	0.95	13	0.95	7	0.51
On raceme in axil of leaf 4...	37	16.30	167	73.57	15	6.61	2	0.88	1	0.44					2	0.88
On raceme in axil of leaf 5...	20	15.75	93	73.23	11	8.66	1	0.78								
On raceme in axil of leaf 6...	38	19.10	144	72.36	11	5.93	2	1.01	1	0.50					1	0.50
Terminal raceme	66	19.19	258	75.00	13	3.72	2	0.58			2	0.58	1	0.29		
Total........	979		3687		424		93		35		47		27		41	

POSITION OF FLOWERS	NUMBER OF CARPELS: 11		12		13		14		15		16		17		18		19		Synanthies		Total
	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	
In axils of Cotyledons........	1	0.17	5	0.84							1	0.17							9	1.52	592
On Branch 1....															1	0.08			13	1.04	1248
On Branch 2....	2	0.15	5	0.38	2	0.15	2	0.15									1	0.15	31	2.33	1332
On Branch 3....	1	0.07	6	0.44	1	0.07													21	1.53	1375
On raceme in axil of leaf 4...							1	0.44											2	0.88	227
On raceme in axil of leaf 5...																			2	1.57	127
On raceme in axil of leaf 6...																			2	1.01	199
Terminal raceme																			2	0.58	344
Total........	4		16		3		3				1				1		1		82		5444

very few flowers while the lower differentiated parts of the plants sustained their flower production to the end of the flowering season.

Floral prolifications in the form of various types of synanthous flowers, often giving rise to syncarpous fruits, were found to be transmitted from generation to generation in fairly constant proportions under given conditions of environment.

The teratological development of the vegetative organs appeared in the form of more or less developed fasciations. Fasciated branches were first discovered on the plants of the fourth generation grown under crowded conditions, in pots. In the next generation, under favorable conditions of nutrition, the fasciated character asserted itself in a manner typical of the ever-sporting races the fasciations being reproduced by half of the progeny.

THE EFFECT OF MILLING ON THE DIGESTIBILITY OF GRAHAM FLOUR

By C. F. Langworthy and H. J. Deuel

Office of Home Economics, U. S. Department of Agriculture

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The bulk of wheat used for flour in this country is made into patent flour which contains about 72% of the wheat kernel. Entire or whole-wheat flour which contains 85% of the wheat and true Graham flour which contains 100% are also we l-known commodities.

The digestibility of patent flour is considerably higher than that of entire-wheat or Graham flours. An average[1] of 31 tests by other investigators with patent flour shows that the coefficient of digestibility for the protein is 88.1% and for carbohydrate 95.7%, while an average of 43 as yet unpublished tests made in this laboratory[2] on patent flour gave the coefficient 89.5% for the digestibility of protein and 99.9% for that of carbohydrate. An average[1] of 23 tests of the digestibility of entire-wheat flour (85% extraction) gave the coefficient 81.9% for the protein and 94.0% for the carbohydrate while an average[2] of 16 tests on similar flour by this office[2] gave the coefficient 87.1% for the protein and 98.3% for the carbohydrate. The average[1] of 24 tests on true Graham flour was 76.9% for protein and 90.1% for carbohydrate and an average of 33 experiments on the same flour by this office[2] gave the value 84.2% for protein and 94.4% for carbohydrate.